Trinity Broadcasting Network
LPTV Maintenance Report Form

Frequency Measuring Points

	Measured	Factory Data
UPCONVERTER L.O.	______	______
MODULATOR	______	______

Output Measurement

Aural Frequency ______

Visual Frequency ______

Transmitter Comments: ______

Satellite TVRO System

	Measured	Normal
"S" Meter Reading	______	______

(x ______ Visual inspection of dish for loose bolts, changes in AZ/EL or damage.

Comments: ______

04054

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Microwave STL System

(x) System Meter readings and/or monitored picture and sound normal

Comments: ______________________________

____

____

Antenna, & Transmission Line Inspection

Check if ok (x)

_______ Visual inspection of antenna & brackets
_______ Visual inspection of transmission line, clamps, and ground system

Tower Structural Condidtion (Check if any conditions below are causing tower to not meet FAA requirements:

_______ Rusting of tower steel
_______ Paint chipping off
_______ Paint badly faded (orange and white stripped towers only
_______ Bolts, tower members loose or bent
_______ Tower noticeably out of plumb
_______ Fraying of guy wires, turn buckles
_______ Damaged guy anchor points
_______ Wrong tension on guy wire(s)
_______ Anyother unsafe condtion (Comments)

____

____

Tower Lighting Sytem (notify us immediately if flashing beacon or strobes out)

_______ Steady burning lights out
_______ Flashing beacon out
_______ Strobe lamp out (stobe lit towers only)

C4055
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Recommended Routine Transmitter

Maintenance Procedures

Ben Miller
(Revision 11/91)

Foreword

From time to time I am asked what specific preventative maintenance items are to be performed during the routine maintenance downtime. Although I have learned through experience (and even some bad experiences) that some of them fall in the "common sense" category, others are not so clear cut. I have therefore, done some research as to what some of the transmitter and tube manufacturers recommend along with some measures I feel are important.

The following pages contain a list of suggested preventative maintenance items which should be performed. This list by no means is meant to encompass everything you should ever expect to do. Some of the procedures will vary from one type of transmitter to another. You could very well see some procedures which don't even apply to your type of transmitter such as items which you do with a liquid-to-air heat exchanger that obviously wouldn't apply to a steam "boiler" type heat exchanger. Likewise items which might pertain to external cavity tubes might not to integral cavity tubes.

There could also be some basic items which were overlooked altogether. If you have any opinions on that please let me know so that I may consider future revisions based on your suggestions.

As most chief engineers find themselves humbly asking for the preventative maintenance time they are permitted, I hope that those station managers who take the time to look this over will gain an appreciation of how much preventative maintenance should actually be performed on television transmitters. It is my desire that the information contained will assist you in better using the brief time you get to try and keep your system running as trouble free as possible.

Ben Miller

Recommended Routine Transmitter Maintenance Procedures

By Ben Miller

This is a listing of legally required and preventative measures which are intended to improve the reliability of the transmitter system. It should be assumed that any specific problem influencing F.C.C. Rule compliance or proper operation of the transmitter should always be given priority over any routine ones.

1. Operating Conditions

Before sign-off, check that there has been no significant change in the values of operating parameters during the past week. A comparison of operating values should be made with the transmitter log pages of the previous week. This check should (minimally) include; beam voltages and currents, body currents, filament voltages and currents, focus currents, water flow and temperatures and reject load power.

2. Cleaning

Cleaning is an important part of the work to be done and should not be overlooked. Excessive dust build-ups in the final amplifier cubicles could mean high voltage "sneak paths" that could at the very least drive you crazy trying to find them and at the most could result in klystron destructive arcs. All external cavity tube ceramic standoffs should be cleaned with either isopropyl alcohol or Freon TF. Beware of other cleaners which can leave a film that can be as bad as dust. Beam supply output ceramics should be cleaned quarterly as well.

Air filters should be blown out or replaced. The floor of the transmitter room should be covered with linoleum so that dust around the transmitter can be kept to a minimum. Mopping should be done regularly. Also, any substantial leaks in the building which might let a lot of dusty outside air in should be plugged as much as possible. Also you should consider gasketing the doors of the transmitter, especially where they meet the floor as well as the outside doors to the transmitter room.

Klystrons which use cooling blowers should have them checked. The first and second cavities should not become excessively dirty as they are reasonably sealed from dust. Because the penultimate and output cavities are cooled with forced air in some transmitters, some dust may accumulate. The amount will depend on the degree of the cleanliness of the transmitter room. Check that the electron gun area (especially the rubbering around the gun ceramics) is clean and that the air filters are clean and in good condition. On a quarterly basis, the exterior parts of the klystron circuit assembly should be cleaned using a dry cloth or paper towels. The klystron and cavities should never be dismantled for cleaning unless you know that the cavities are dirty or are giving trouble.

3. Water System

The water system should be checked at regular intervals to ensure that the reservoir is filled to the appropriate level and clear and free of solids. Observation should be made for any foaming or bubbles in the coolant reservoir or flow gauges. Any unusual discoloration of the water may indicate impurities or rust in the system. Under these conditions, the system should be drained and replenished with clean distilled water (or glycol mixture in winter.) The plumbing in the heat exchanger system should be inspected by visual observation at sign-on following the maintenance period since this is the time when the water is usually the coldest and when leaks in the system will be most likely.

Those stations requiring a glycol mixture should take particular care to make sure that the glycol being used is one which has been verified by your tube manufacturer to be acceptable for your application. At this time, Dow Chemical's "Dowtherm SR-1" is most widely recommended. When obtaining Dowtherm, particular attention should be paid to the quality of the substance being delivered. The first thing you should do is obtain an SR-1 specification sheet so you can understand the description and physical properties of it. Apparently, many suppliers have been opting for obtaining larger quantities and then decanting the SR-1 into their own containers. Although this may not necessarily be a problem, you can never know what was previously in the container they used, or how thoroughly it was cleaned before the SR-1 was poured into it. If contamination levels of certain substances is high enough, it could cost you a premature failure of a klystron. If you are unable to obtain the SR-1 in the red and white factory original container, or otherwise have reason to believe that your supplier is not providing you with exactly what is on the SR-1 specification sheet, you should look for another source. There have even been cases of delivery of barrels of substance the supplier called SR-1 which wasn't even the correct color!

The water flow through the klystron, as indicated on the flow meter, should be noted at "sign on" and periodically during the day (if you have means of doing so in a remote controlled transmitter) to ensure the water system is operating correctly. Any unexplained changes in the klystron water flow should be regarded as a warning that some portion of the system may have become clogged with foreign matter or that the heat exchanger pump may be defective. If your transmitter uses a liquid-to-air heat exchanger, verify that it has an inline water filtration system rated to 5 microns. If it does not, plan for it's installation as soon as possible. Once installed, check the filter bag regularly for replacement. Keep plenty of spares on hand.

Perform pH and conductivity testing quarterly to determine the acidity and contamination level of the water. The pH factor should be within the range of 6.0 to 8.0. With a 50% Dowtherm SR-1/Distilled water solution the pH factor will come up to 9.0 - 9.6. Hyperacidity, defined as pH values under 6.0, when left unchecked could result in the breakdown of the solder joints in the system or coils of the exchanger unit. That would then result in profuse leaking which calls for the discarding of the entire unit. Also the same process could very well result in substantial metallic contaminants which could clog the collector of the klystron resulting in tube damage or destruction. Obtain either a pH test kit or litmus paper.

Flush your system at least twice each year. Transmitters located in areas prone to winter freezes should complete this process when the change is made from summer and winter operation. Summer operation calls for use of only pure distilled water to be used in the system. In the fall, when the hard freeze days near, system should be flushed replenished with a Dowtherm SR-1/distilled water mixture appropriate for the area. In no circumstance should a mixture greater than 50% SR-1 ever be used. The reverse of this procedure should be performed in the spring after the last expected hard freeze day. After the Dowtherm SR-1 is drained, the system should be flushed with either trisodium phosphate (TSP) or Tygloss (manufactured by TySol). Approximately one gallon should be added to the system and left running for approximately 20 minutes. <u>Do not run the mixture through the klystron collector</u>, it can be bypassed with one of the water hoses. Drain the system and flush with plenty of tap water.

Next perform the <u>foaming test</u>. The following procedures is based upon the one published by Colin Erridge of Varian Associates as pertaining to vapor cooled klystrons. The same basic procedure is also useful in testing for foam in liquid-to-air heat exchangers;

If impurities are present (in the water) foaming may occur. This will inhibit heat transfer, thereby lowering the cooling efficiency of the system. The following is a list of impurities that may cause foaming, and directions on how to perform a foaming test.

Impurities that most frequently produce foaming are:

* Cleaning-compound residue.
* Detergents.
* Joint-sealing compounds.
* Oily rust preventatives in pumps and other components.
* Valve-stem packing.
* Impurities in tap water.

The following test should be performed after each water change, system cleaning or modification.

<u>Equipment</u>

The following items are needed to perform the test:

* A 1/2" X 4" glass test tube with rubber stopper.

* A 1-pint glass or polypropylene bottle with cap.

Procedure

1. Fill the cooling system with water and circulate until thoroughly mixed (approximately 30 minutes).
2. Drain the sample of water into bottle and cool to room temperature.
3. If the water sample stands for more than one hour, slowly invert the capped bottle about 10 times. Avoid shaking the bottle because this will create air bubbles in the water. (When the water is static, foaming impurities tend to collect at the surface. This step mixes sample without generating foam.)
4. Using sample water, rinse the test tube and stopper three times.
5. Half fill the test tube with sample water.
6. Shake the test tube vigorously for 15 seconds.
7. Let the sample stand for 15 seconds.
8. Observe the amount of foam remaining on top of water and evaluate.

Evaluation

A completely foam-free water surface and test-tube wall indicate no foam-producing impurities. If the water surface and test-tube wall are partly covered with foam, but a circle of clear water appears in the center, the impurity level is temporarily acceptable. A second test should be made in approximately one week.

If the foam layer completely bridges the inside of the test tube, the system should be flushed and cleaned.

A suggested seasonal flushing procedure is to fill the system with tap water, open the drain and run the system continuously filling and draining at the same time. Let this process continue for about an hour allowing the system to flush itself. When the water smells and feels clean, flush once with distilled water once finally filling with distilled water (or SR-1/distilled water mixture in the fall). At the completion of this process it would be a good time to perform a pH check. It should be understood that the best possible coolant for which your cooling system was designed is distilled water. Glycol should be removed as soon as possible when there is little possibility for a hard freeze.

If you notice the collector temperature running progressively higher than it used to, you may be the victim of a dirty heat exchanger. The bottom of the core of the liquid-to-air heat exchangers should be checked for anything impeding the air flow. Clean annually, or more often if required. This should be done with a service which uses a high pressure hose system. Make sure to remove the fan blades and fan guards. Spray from top to bottom taking care not to damage the core.

4. R.F. System

The R. F. plumbing leaving the klystron in most external cavity tubes is 3-1/8" coaxial line. A slip fit connector is usually connected to the coaxial line in the cabinet. An inspection should be made to ensure that a tight fit exists with all clamping hardware. Looseness could be the cause of losses and overheating in the output stack resulting in possible destructive burn out of the stack, or worse, the destruction of the tube through arcing and reflected power.

Even before the shut down of the transmitter prior to the commencement of the maintenance period, reach in and feel the outside temperature of the output stack. If it is too hot to keep your hand on, there is probably a problem in the making. The stack either has loose connection of the inner or outer conductor, or is otherwise exhibiting a high impedance or mismatch to the tube output which could eventually lead to real problems. They should be resolved as soon as possible. An additional preventative measure would be install a temperature sensing probe on the outer conductor, tied to a meter having warning and trip point settings. The meter should then be tied to the fault trip interlock control ladder of the transmitter. You can take this one step further by making the temperature readings available in any spare telemetry channels for remote controlled transmitters.

Perform a measurement between the collector and ground. It should read infinite.

Additionally, when checking these items for overheating, also feel the output coupler and cavities during operation for any apparent overheating. On a quarterly basis, the collector-body resistance of the klystron should be checked with the collector cable disconnected from the water jacket. This measurement is normally made between the collector terminal and the ground stud on the magnet frame. Another check which is valuable is one performed to determine the resistance value of the water hoses serving the collector. Hoses which read less than 100 megohms could be the cause of false and excessive body current measurements. Replace low resistance hoses.

The coaxial system associated with the transmitter, combiner, diplexer and transmission line exiting the building should be checked as often as possible during operation for "hot spots." This should especially be done around flanges, elbows and joints. Also checks should be made to ensure proper dry air or nitrogen pressure is being maintained in the output line system. Find out what the "normal" duty cycle of your dehydrator is and whether or not it is more frequent than it should be. Likewise the loss rate in a nitrogen system should be checked.

Stations using coaxial transmission line should check the impedance integrity of their line on an annual basis. A Time Domain Reflectometer (T.D.R.) with strip chart recorder is available from the Trinity Broadcasting Network Headquarters on sufficient notice to make this check. Of course, any apparent coaxial transmission difficulties manifest by higher than normal standing wave ratios, jumps in standing wave ratio without explanation, reflected signal or "ghosting" detected on the demodulated signal and waveform at the transmitter site, should be cause for further investigation of a transmission line or antenna problem. The T.D.R. should be immediately called for to assist in determining whether the problem is in the line or elsewhere.

5. Klystron Beam Power Supply

In those transmitters having outdoor oil filled unitized beam supplies, it is not considered necessary to open the transformer cases for routine maintenance. If an oil filled supply is used, the oil level should be checked weekly as indicated on the gauges attached to the power supplies. Oil leaks should be looked for. Care should be taken to exclude water from the terminal boxes and conduits. At least once a year, terminals on the power supply and breakers which supply power should be checked for tightness.

Stations using beam supplies manufactured by Aydin Corporation must become aware of a particularly serious failure mode which that manufacturer's products are prone to. For reasons still not completely understood, catastrophic transformer failures have occurred at Townsend transmitter installations. The present theory is water contamination in the transformer oil. Knowing this, you should take all necessary precautions to protect your transformers. You can combat the effects of contaminated oil by having periodic samples of your oil taken and checked for levels of water contamination as well as "high voltage standoff" as measured in kilovolts. If the water contamination goes above 30 parts per million, or the voltage standoff approaches within 25% above the actual beam supply voltage (switched to delta) it is time to immediately filter or replace the oil. Another inexpensive "insurance policy" is to positively pressurize the supply with nitrogen.

6. Exciter System

Unless specific problems with the exciter system require attention, the only routine check which might be indicated is a frequency check, which should be taken with a frequency counter. A reading should be made of aural, visual and intercarrier frequencies. These readings should then be compared against the frequency deviation meter at the transmitter control point. If you use an outside frequency measurement service, the results of your check should be compared with their last report. A further improvement over that would be a pre-arranged measurement taken simultaneously, with your results compared over the telephone. As the results of the outside service is much more likely to be closer in accuracy, the deviation noted in your counter and deviation monitor should be a cue to have these instruments calibrated if the accuracy is significantly off.

Make sure to log the results of all frequency checks. Any observation of the aural or visual carriers being near or in excess of the tolerances set in the F.C.C. Rules calls for immediate remedial action prior to sign-on.

7. System Sweep

Although not all stations have spectrum analyzers and sideband adapters, all should, at least, have access to them. Those which do have them should keep them set into a test configuration where the sweep signal can be quickly routed into the exciter and the analyzer readily patchable into a directional coupler. Where this can be done, it is determined that just a few minutes of sweep testing done weekly, can reveal a lot about both the response of the transmitter, and more importantly, it's spectral efficiency. Open or defective cavity loads can contribute to such problems and should have resistance checks performed on them on a quarterly basis. Undetected spurious radiation, harmonics and lack of lower sideband attenuation are some of the most likely areas in which Notices of Violation" form the F.C.C. are commonly issued, as they can be monitored in the field.

FCC rule 73.1590 (b) reads:

(b) Measurements for spurious and harmonic emissions must be made to show compliance with the transmission system requirements of 73.44 for AM stations, 73.317 for FM stations and 73.687 for TV stations. Measurements must be made under all conditions of modulation expected to be encountered by the station whether transmitting monophonic or stereophonic programs or providing subsidiary communications services.

(5) Data showing the attenuation of spurious and harmonic radiation, if, after type acceptance, any changes have been made in the transmitter or associated equipment (filters, multiplexer, etc.) which could cause changes in its radiation products.

Rule 73.687 referred to above reads:

(e) Operation. (1) Spurious emissions, including radio frequency harmonics, shall be maintained at as low a level as the state of the art permits. As measured at the output terminals of the transmitter (including harmonic filters, if required), all emissions removed in frequency in excess of a 3 MHz above or below the respective channel edge shall be attenuated no less than 60 dB below the visual transmitter power. (The 60 dB value for television transmitters specified in this rule should be considered as a temporary requirement which may be increased at a later date, especially when more higher-powered equipment is utilized. Stations should, therefore, give consideration to the installation of equipment with greater attenuation than 60 dB.) In the event of interference caused to any service, greater attenuation will be required.

In the interest of meeting the provisions of this rule, stations should perform spurious and harmonic measurements as often as necessary to verify compliance with the rule, but certainly not less often than once a year and certainly anytime transmitter work is performed which might effect spurious and harmonic energy content.

So that the harmonics can be properly measured, if you don't presently have a tunable notch filter for use with your spectrum analyzer to reduce primary visual carrier frequency overload, you should obtain one. Spectrum analyzers have certain limitations that must be considered before attempting measurements. Harmonic measurements require the spurious free dynamic range of the instrument to be considered. If the analyzer to be used has a 70 dB dynamic range it will be useful for signals over a dynamic range of 60 to 65 dB. Additionally, the 70 dB specification occurs at a specific input power to the analyzer's mixer. By various combinations of internal and external attenuators this power level can be obtained.

In making a harmonic measurement of 75 dB, the above limitations are apparent. By carefully limiting the input power to the maximum undistorted level, the noise floor is at about -70 dB on the CRT, effectively masking the harmonic at -75 dB. By removing 10 dB of attenuation, you cause the harmonic to increase 20 which is a definite indication of overloading on the mixer of your spectrum analyzer.

The harmonic dynamic range can be increased by the use of a tunable notch filter. Tune the notch filter to the fundamental (visual carrier) frequency, remove 10 to 20 dB of input attenuation on the analyzer as required and the harmonic at -75 dB can now be accurately seen. Overload on the instrument is no longer a problem because the notch filter is attenuating the fundamental frequency signal which was causing the overload.

Prior to installing the notch filter to the input of the analyzer you must measure the fundamental frequency for a reference. Take a sample from the system output and feed it to the input to the analyzer. Set the peak of the visual carrier to a reference on the CRT where it doesn't overload the instrument. Now insert the notch filter and tune out as much of the signal as possible. You should now be able to tune to the harmonic frequency, remove some attenuation, and accurately measure it's level.

If you measure the harmonic to be 55 dB down from the reference set to the visual carrier, and you removed 20 dB of attenuation, then the harmonic is 75 dB down from peak visual carrier. You should be careful to not remove so much attenuation that it will cause the fundamental to overload the input. Even if you have changed frequency and no longer see the fundamental, the energy is still present.

The following page is a suggested form which you can complete each time spurious and harmonic measurements are performed. This information is also being provided to affiliate stations as a suggested engineering practice.

FCC Rule 73.687 (e) Spurious and Harmonic Emissions
Measurements Report Form

Station Call Letters__________
City____________________

The following measurements were made with the aural and visual transmitter and all associated equipment, including the harmonic filters, combiner (if applicable) and diplexer, operating into the antenna.

A sample was taken at the output terminal of the diplexer and coupled to a ______________________ spectrum analyzer. The visual power was referenced to 0 dB and filtered with an Eagle model TNF-230 notch filter to avoid input overload to the instrument from the primary visual carrier frequency.

All emissions removed in frequency in excess of 3 MHz above or below the channel edge were measured at -60 dB or less and recorded below.

Assigned Visual Carrier Frequency____________ MHz

Emissions (if detectable)	____________	MHz	____________	dB
Second Harmonic	____________	MHz	____________	dB
Third Harmonic	____________	MHz	____________	dB

____
Engineer Performing Measurements

____
Date

This form should be filed along with the Station Log and made available for FCC inspection.

If your facility does not have it's own spectrum analyzer, then one should be borrowed at least quarterly. Again, any and all test results from use of the spectrum analyzer and subsequent adjustments to the transmitter system should be thoroughly logged. The F.C.C. Rules specifically require these periodic spectral efficiency checks, and if one is not in evidence in your logs at least on an annual basis, a violation citation could result.

One notch filter which is frequently used can be obtained from:

Eagle Wichita
P. O. Box 9446
Wichita, KS
Phone: (316) 942-5100
Fax: (316) 942-5190

Model #TNF-230
Price: $99.00

8. Aural Carrier Deviation Check

Aural carrier deviation checks can be performed against the accuracy of the station's modulation monitor(s) using the Bessel function of the spectrum analyzer. Learn how to do this and then schedule it periodically. Results and re-calibration should always be logged.

9. High Voltage Beam Contactors

Depending on what type of high voltage beam contactors are used, periodic maintenance could be required. Far instance, the spring-loaded type should have an annual servicing by a manufacturer's representative. During this visit the device should be inspected and if necessary, the shunt trip time constant set. If you are unsure what the service-requirements are for the type of contactor used in your installation you should check with the manufacturer.

10. Arc Detectors

Most arc detectors are installed in pairs for each klystron and are usually a fiber optic/photocell arrangement which reacts to light. Most also have a test circuit which should be exercised weekly. If you have intermittent, or failure to operate, consider that as cavities get older, the oxidize and the reflection of the test lamps might not be enough to lower the impedance of the photocell. Cleaning the third and fourth cavities and the face of the photocells will solve this problem. Don't dismantle these cavities unless you are sure that you are experiencing this problem.

11. Remote Control Meter Calibration

This should be performed weekly in those stations which use either remote metering circuits or remote control systems. The F.C.C. Rules require that all remote metering must be within 2% accuracy.

12. Waveform Analysis

Although waveform analysis should be an ongoing activity by both operations personnel and the Chief Engineer, particular attention should be paid to the transmitted waveform when access is available to the transmitter during sign-off so that adjustment can be readily available.

Transmitters which use annular beam control or modulating anode type pulsers are particularly in need of attention, as waveform distortions are usually the unfortunate by-product of beam efficiency techniques resultant from the use of these devices. You may find yourself treading the fine line between F.C.C. Rules violation and maximum beam efficiency. The area in which the line is first stepped over is in sync variation violations resulting from sync tip overshoots, spikes or amplitude problems. Equalizing pulse width and vertical sync interval should also be scrutinized, particularly on pulsed transmitters.

Running on the ragged edge between of efficiency and F.C.C. compliance means you must devote constant attention to the fine art of pre-correcting the exciter input and output to satisfy (among others) differential gain, differential phase and incidental phase modulation not to mention short and long duration waveform distortion limit requirements at the transmitter output. Persons new to this should enter in to this area cautiously and accept instruction from the manufacturer or other qualified personnel before making any major adjustments. Stations using Townsend TA Series exciters should be particularly careful in making exciter adjustments due to the possibility of interactivity. Your actions may cause reactions in unexpected areas.

Stations in possession the Tektronix 1450 demodulator should be able to set-up for the measurement of incidental phase modulation. Depth of modulation should also be checked and verified.

13. Transmitter Protection Circuits

All transmitters share one universal feature, and that is an interlock ladder of protection circuits in which one or two states of protection exist. Some of these consist of devices that can be set to indicate a warning level, and do so by driving an indicator lamp or other type of warning. Continuation of the same fault condition to a higher level then results in an outright protection shunt trip removal of the high voltage current to the final tube. Other circuits have only the final protection trip design. The sensing devices take on many forms such as thermal probe/meter combinations, flow meter or switch devices, current sensors, phase presence monitors to name a few. If you neglect these devices, particularly the mechanical ones, you are flirting with potential disaster. They can and do fail. And many times the mode of failure is for the device to simply cease detecting fault conditions. I cannot over-emphasize the importance of weekly checks of as many fault circuits as practical.

A recommended test procedure is to disable beam current to the final tube followed by artificial inducement of fault conditions which are supposed to result in a high voltage trip. Circuits which should be minimally checked should include;

* Loss of focus or magnet current(s) - OF CRITICAL IMPORTANCE
* Body Current
* Beam overvoltage
* Beam overcurrent and high voltage S.C.R. (Townsend)
* Overtemperature
* Arc detectors
* Water flow
* Power line phase loss
* VSWR
* Filament current loss

Faults resulting in magnet or focus current loss are of particular importance as destruction to the klystron drift tubes can occur in literally microseconds! Hence the reason for high voltage contactor time constant checks as covered earlier.

Some transmitters include a test or lamp test mode which applies current to a number of status and control indicator lamps and latch circuits. Use this function to identify faulty circuits and open lamps. Repair the circuits and replace the lamps as required. Some test circuits also will activate the high voltage trip.

Methods of performing these tests will vary from one make of transmitter system to another. If you don't have sufficient information to determine how to perform all of these checks, then the manufacturer should be consulted on how best to perform them.

14. System Meter Checks

Although the most frequently read meters on a transmitter tell us much about it's operation, other, less frequently read (and sometimes overlooked) ones can tell a subtle tale about the general health of the klystron. This is especially true about the body current, filament voltage and current meters. Do not ignore changes in these as they are a major element to understanding what is going on in a klystron. You should contact the klystron manufacturer to discuss the significance of any recent changes in these parameters, and particularly any that exceed the nominal values in the klystron specifications. The same holds true for any instabilities in these values which are not easily explained. Never attribute unusual or unstable readings to a defective meter or driver circuits. If there is no doubt that such readings are the result of defective metering circuits, they should be repaired without delay. The man-hours and part costs of doing so are infinitely less expensive than a new klystron!

For instance, a filament overvoltage condition left unresolved can cut the klystron life in half. A weekly check should be made across the terminals of the electron gun with a digital voltmeter to determine if the filament voltage is within the specified range for that particular klystron taking regard to it's age. This simple procedure could save an incredible amount of frustration and money.

15. Power Calibrations

The provisions of FCC rule 73.663 regarding power calibration of visual television transmitters reads:

(b) Direct method, visual transmitter. The direct method of power determination for a TV visual transmitter uses the indications of a calibrated transmission line meter (responsive to peak power) located at the RF output terminals of the transmitter. The indications of the calibrated meter are used to observe and maintain the authorized operating power of the visual transmitter. This meter must be calibrated whenever any component in the metering circuit is repaired or replaced and as often as necessary to ensure operation in accordance with the provisions of 73.1560 of this part. The following calibration procedures are to be used:

(3) The meter must be calibrated with the transmitter operating at 80%, 100%, and 110% of the authorized power as often as may be necessary to maintain its accuracy and ensure correct transmitter operating power. In cases where the transmitter is incapable of operating at 110% of the authorized power output, the calibration may be made at a power output between 100% and 110% of the authorized power output. However, where this is done, the output meter must be marked at the point of calibration of maximum power output, and the station will be deemed to be in violation of this rule if that power is exceeded. The upper and lower limits of permissible power deviation as determined by the prescribed calibration, must be shown upon the meter either by means of adjustable red markers incorporated in the meter or by red marks placed upon the meter scale or glass face. These markings must be checked and changed, if necessary, each time the meter is calibrated.

Rule 73.1560 (c) reads:

(c) TV stations.

(1) Except as provided in paragraph (d), the visual output power of TV transmitter, as determined by the procedures specified in 73.663, must be maintained as near as is practicable to the authorized transmitter output power and may not be less than 80% nor more than 110% of the authorized power.

(2) The output of the aural transmitter shall be maintained to provide an aural carrier ERP not to exceed 22% of the peak authorized visual ERP.

These rules call for television transmitter power calibrations to be performed "as required" which means if they ask for one to be performed in their presence, it had better be correct! E.E.V. recommends that they be done quarterly. If you use a through-line watt meter, it should be checked against a more standardized method as they are not particularly accurate. They can be helpful for occasion quick verification, but the actual periodic calibration should be done using the calorimetric method in liquid-to-air heat exchanger transmitters.

The following power calibration form on the next two pages can be useful for logging the results of your calibrations and filing with the Station Log as required. You should substitute the wording in the first paragraph regarding the method of reading power if you use calorimetric method (flow and thermometers) instead of a thru-line wattmeter.

If you do use the calorimetric method, you should include a paragraph describing how your calculations were made to arrive at a correct power figure. If you have glycol solution in your water, make sure you include the correction factor. You can arrive at this factor either using the Dow Chemical data charts, or with the computer program written by Doug Lung. A good place to find wording for this description is in the power calibration portion of the original manufacturer's proof-of-performance which was performed when your transmitter was first installed. This should be in your files.

Reflectometer Calibration

FCC 73.1560 (c)

Station Call Letters__________
City______________________

The following measurements were made with the aural and visual transmitter and all associated equipment, including the harmonic filters and diplexer, operating into a Bird Thruline watt meter coupled to an Altronic water cooled load.

The transmitter was adjusted to it's calculated 80%, 100% and 110% power levels as indicated by the watt meter, and compared to the actual reflectometer reading.

The reflectometers were calibrated at 100% power before the remainder of the measurements were made. The red pointers on the reflectometers were adjusted to indicate 80%, and 110% power levels.

All visual average power readings were taken with 25% sync only, and checked with a Tektronix model 1450-1 demodulator. The beam voltage and current were also measured at this time.

Engineer____________________

Date______________________

0108

Visual Power Calibration: Transmitter ________

Beam Volts	________	KV
Beam Current	________	Amperes
Power Level	80	%
Average Power	________	KW
Calculated Peak Power	________	KW
Actual Reflectometer	________	%
Power Level	100	%
Average Power	________	KW
Calculated Peak Power	________	KW
Actual Reflectometer	________	%
Power Level	110	%
Average Power	________	KW
Calculated Peak Power	________	KW
Actual Reflectometer	________	%

Aural Power Calibration:

Beam Volts	________	KV
Beam Current	________	Amperes
Power Level	80	%
Average Power	________	KW
Calculated Peak Power	________	KW
Actual Reflectometer	________	%
Power Level	100	%
Average Power	________	KW
Calculated Peak Power	________	KW
Actual Reflectometer	________	%
Power Level	110	%
Average Power	________	KW
Calculated Peak Power	________	KW
Actual Reflectometer	________	%

16. Lubrication - Belts

Pump motors, fan motors, squirrel cage fans and other moving parts call for periodic inspection and a lubrication schedule on all applicable units. These are usually the "non-sealed" type which have provision for oiling and zirk fittings for greasing. Determine the locations of all such requirements and, wherever possible, what the manufacturer's recommended lubrication specifications are. Make sure that you have all the necessary ones in stock along with oil cans, grease gun and even WD-40. Also, the condition of all belts, hoses and items subject to mechanical deterioration should be checked and replaced as necessary. Make sure your spares stock is ready in anticipation of these replacements.

There is little excuse for a predictable failure occurring for which a spare was never anticipated or ordered.

17. Parts - Tools Inventory

A less exotic, but frequently overlooked area of transmitter system maintenance is. the condition of the workbench and spares inventory. What is the condition of your workbench and tool compliment? Have tools been borrowed for your studio and not returned? Have you installed parts spares for which another might be called for in the foreseeable future, and not re-ordered replacements? Have you kept up a modest, well organized stock of garden variety resistors, capacitors, fuses etc.? How about spare control and time delay relay replacements? Those are easily obtained through most electrical or electronic wholesalers at a lower cost than through the transmitter manufacturer. How about klystron bias resistors which are subject to occasional failure? At some point in time you will experience a water pump failure. A good idea is to order a new replacement motor and keep the spare one as a "re-buildable" unit which should then go into service as a replacement for the next failure. The next failed one should then be rebuilt and so on.

The point is that time spent evaluating spares and tools can be just as important as actual "hands-on" transmitter maintenance, and can be performed at any time, not just sign-off.

18. Inspection of Premises

Transmitter installations which are located at remote sites spend the majority of time unattended. A "walk-around" both the inside and outside of the premises should be performed. The general condition of the inside of the building makes an impression of the F.C.C. inspector during that inevitable inspection visit. Boxes laying around, transmitters operating with cabinet or cubicle doors open, clip leads and other temporary connections hanging out of the transmitter cabinets, coax and signal wires suspended between the monitoring console and the transmitter which can act as a "hangman's noose" to unsuspecting victims, all will surely invite closer scrutiny by the inspector. The inspector will inevitably deduce that similar lack of professionalism could very well exist in efforts to comply with the F.C.C. Rules.

All wiring should be permanently and professionally run and laced in. All transmitter cabinet doors should stay closed and sealed during non-maintenance times. If doing so results in overheating, find the cause and fix it. Install additional fans or even duct in building air conditioning if necessary. Cabinets should be built to store your parts and spares inventory. If you don't already have one, build a functional tool and workbench area and equip it properly for what has to be done. All of these things are relatively inexpensive to accomplish and, if outside help is needed to build the bench or cabinets, your station manager should cooperate in obtaining the help and budgetary approval for the tools and spares if it is in the interest of improved reliability of the transmitter.

Outside the building, when performing the weekly power supply and heat exchanger checks, do a full "walk-around" of the outdoor premises. Check for the need for mowing, weed and pest control. Check for possible fire marshall violations. See to it that all boxes, pallets and general garbage items are hauled off. What is the condition of the exterior paint of the building? How about the chain link fencing securing the perimeter? Any damage, or attempted break-ins? Check the condition of the dead-bolt lock on the building door. Any attempted break-in damage? Does your remote control intrusion alarm work properly. If you don't have one, it can be simply added to a status function of your remote control system and tied to an annunciator at the studio. Do any of the outside lighting fixtures need lamp replacement? Is there any unrepaired ice damage to the building roof, air conditioners heat exchangers or canopy area?

19. Tower

The F.C.C. Rules call for a "quarterly" tower inspection which calls for scrutiny of the general condition of the tower structure, paint and aviation obstruction lighting. They do not elaborate on how this is to be accomplished. The important thing to understand is that if they find a non-compliant condition which you didn't, the method used is obviously short of the requirement. Any time tower riggers are engaged to climb your tower for any reason, ask them to perform a cursory inspection of all conditions as they climb. They should also be asked to perform any needed bolt tightening and any (non-strobe) lamp replacements needed resulting from their observations. All observations and subsequent actions should be fully logged. Unless these visits come close in time to a previous re-lamping visit, the scope of work to be performed should include a full re-lamping.

Tower "plumb and guy tensioning" should be performed every 2-3 years. Otherwise, when riggers are not being used, you should see to it that as comprehensive as possible ground inspection be performed. You might consider using binoculars on tall towers to detect unsafe conditions which might not be seen otherwise.

Check for lamp outages which might have been unreported. Look for paint peeling and fading. Also check for any obvious structural problems which need attention. Towers using aviation obstruction paint should obtain a paint reflectivity chart with which to compare the paint condition.

Check the condition and tension of all spring hangers on the transmission line. Are some of them topped or bottomed out? If this is the case during non-extreme outside temperature conditions, a problem which could result in line damage might exist. Likewise when simultaneous topped and bottomed out hangers are observed. Occasional walks out to the guy anchors should be made to check their condition.

20. Training

Most of us got our "hands-on" transmitter maintenance training from someone else, and your assistants should likewise benefit from your experience and knowledge. Whenever possible, you should arrange the schedule of people which you wish to designate as transmitter maintenance trainees to spend time with you during sign-off so that they may benefit from some "hands-on" time. Tutorial conversations and explanations will help in the training process. Bear in mind that the person(s) whom you are training could very well be your sick or vacation relief, so train them to good confidence level.

21. Mid-Week Maintenance

Those with remotely located transmitters, not currently scheduling a mid-week maintenance trip may eventually find themselves not keeping up with all requirements. You should consider, for no other reason than the availability of daylight, performing many of the outdoor check-out requirements which don't require sign-off. Many other items can be taken care of inside without transmitter shut-down, also. The mid-week trip can be very helpful in making optimum use of transmitter sign-off time.

22. Time Management

Some of the recommended maintenance items I have noted are not necessarily to be given weekly attention. For that reason, they are easily overlooked and neglected because they are not part of a routine. As a result, I feel that the best plan of attack in accomplishing everything which should be done in an effective transmitter maintenance program is to take a lesson from time management experts and "budget" the responsibilities out over time. That way the additional non-weekly responsibilities can be added to the weekly ones in a manageable schedule.

Lack of planning results in a situation where a lot of postponed items cluster up and create a situation where the weekly ones are dropped to perform the neglected ones. Or, just as bad, the non-weekly ones lapse overdue to place you in possible F.C.C. Rules violation.

Sit down and write out a comprehensive list of all of the maintenance requirements which are non-weekly, and list the frequency of when it must be done; i.e. quarterly, six-month, annual. Then obtain a calendar which you can post in a prominent location. This can be referred to each week before planning your sign-off duties for the week. Pick an item from the non-weekly list you made and pencil it in on your map on sign-off periods at the correct intervals. Say for instance you schedule your tower inspection for the first Monday mornings in January, April, July and October. You then try to minimize scheduling any other non-weekly items on these dates. Then go on to schedule your water pH and conductivity check on the second weekends of January, April, July and October. Then schedule your cavity load resistance checks on the third weekends of those months, etc.

You may have so many non-weekly items that it is impossible to keep them to one per weekend, but at least you have time budgeted yourself into a position where you will hopefully not be confronted with an incredible backlog of unperformed requirements.

23. Power Outages - Protection of Klystrons

Colin Erridge of Varian Associates provides the following information on the subject of getting optimal service from klystrons under the adversity of power outages;

Powering up and shutting down klystrons requires some care, especially with remote-control operation. Improper procedures in the regard can destroy klystrons quickly.

Proper shutdown procedure is a matter of the order in which the components of a system are turned off. it is essential that the high voltage to the klystron be shut off first. Verify this by checking for a positive reading of zero on the transmitter's anode voltmeter oar the corresponding remote-control reading. Under normal shutdown, if this reading does not drop to zero, proceed no further until the high voltage is manually removed via the high-voltage off switch, or by mechanically tripping the high-voltage breaker. Only when the anode meter reading verifies that the anode voltage is zero should power be cut to the electromagnets, pumps and control circuits of the transmitter.

Power Service Outages

A nice, orderly shutdown is not always possible. Even at facilities equipped with